CHAPTER 5: PHYSICAL HABITAT DESCRIPTIONS

INTRODUCTION

Since November, 1992, the abundance of aquatic habitat types has been quantified for distinct portions of the San Juan River. This has been accomplished by ground crews mapping upon images obtained from aerial videography of the river at various discharges. The number of categories used to delineate aquatic habitats has expanded during the study as researchers have made improved distinctions between different habitat types. Presently, there are nearly 40 different types described (Table 5.1). However, the vast majority of the habitat present in the river at any time is comprised of only several types. Runs typically compose at least 70% of the total habitat, regardless of discharge. Secondarily in abundance are usually riffles and riffle-runs. Combined, these three constitute approximately 85-90% of the total habitat (Bliesner and Lamarra 1996). The remainder is comprised primarily of shoals and low velocity types like slackwaters, pools, and backwaters.

In the winter of 1994, a study was initiated to characterize the major aquatic habitat types in the San Juan River using a number of different physical measures. These included mean water column velocity, depth, embeddedness of substrate, and substrate composition. Initially, the principal goal was simply to determine whether and how individual habitat types differed and whether original habitat definitions obtained from the U.S. Fish and Wildlife Service and New Mexico Game and Fish were valid or of sufficient detail. Subsequently, it became important to understand whether particular habitats changed in various physical measures of quality through time and space. This latter objective was undertaken as the potential impacts of frequent storm events in the drainage on habitat quality became more evident and more of a concern, particularly with regard to the ramifications toward on-going efforts to recover the endangered Colorado pikeminnow and razorback sucker. For example, a decrease in the depth of some low velocity habitats following summer storms, particularly backwaters, was observed during the first few years of the study. Some backwaters were physically cut off from the river by sand bars and others completely filled in with fine sediments. These habitats have been identified as important to the early life stages of Colorado pikeminnow and other native fishes in the San Juan River (Buntjer et al. 1994, Archer et al. 1995, 1996) and elsewhere in the Upper Basin (Valdez et al. 1982, McAda et al. 1994). It was also suspected that the productivity of different habitats would be reduced following these storms, at least in the short term, as a number of studies have indicated (Niemi et al. 1990, Meffe and Minckley 1987, Fisher et al. 1982, Kennedy and Tash 1979). This could have profound implications for the condition of various life stages of the native fish community. Eventually, two studies were initiated to address these issues in detail and are summarized in separate reports.

METHODS

A total of eight habitat types were selected for study, based either on their abundance or their perceived importance to native fishes. These included riffles, riffle-runs, runs, cobble shoals, eddies,

Table of Contents

slackwaters, pools, and backwaters. Within each habitat, water velocity, depth, depth to the embedded layer of substrate, and substrate composition were quantified. Water velocity was measured in centimeters per second at several equidistant points along four or five transects in each habitat using a Marsh-McBirney current meter at 60% total depth. Depth was measured in feet (to nearest 0.1 ft), but later converted to meters. Depth to the embedded layer (DTE) was considered to be the distance to the layer of substrate completely embedded by fine sediment. This was determined by working one's hand into the substrate until the embedded layer was reached and then measuring that distance to the nearest centimeter. It was determined at four to ten random points in each habitat. One composited sample of interstitial substrate was taken at several random points in each habitat using a 5-cm diameter PVC coring tube inserted below the surface layer. This sample was stored in a zip-lock bag and later dried and sieved for determination of the percent composition of various size fractions by dry weight. Fifty randomly selected particles of substrate were measured along the y-axis (intermediate axis of the three axes with respect to depth) within each habitat to the nearest 0.5 centimeter (Wolman 1954). Sand and finer substrate was classified as less than 0.2 cm. Pebble count and interstitial substrate composition data were integrated for each habitat to provide a more complete depiction of the percent composition of the substrate present.

The San Juan River was arbitrarily segregated into three non-contiguous sections. These were: Section 1 (RM 224-195, or Navajo Dam to Bloomfield, New Mexico, bridge); Section 2 (RM 158-119, or Hogback diversion to Four Corners, New Mexico, bridge); and Section 3 (RM 93-52, or Montezuma Creek, Utah, bridge to Mexican Hat boat launch) (Figure 1.1). The delineation of sections was largely access-driven, but was intended to incorporate the majority of the river with some separation between sections. Sampling occurred a total of four times in November-December, 1994, and February-March, August, and September, 1995. However, during the first two trips sampling occurred in Section 2 only. During the third trip in August, 1995, sampling occurred in Sections 1 and 2 only. During the last trip in September, 1995, sampling occurred in all three sections. Hence, only Section 2 was sampled during all four trips. Four to six habitats of each type were sampled per section during a particular trip. Sampling during the first two trips was geared toward merely describing the specific habitat types, while sampling during the last two trips began to address the issue of spatial and temporal differences within habitat types during the summer-fall storm season.

RESULTS

Discharge throughout the four trips was fairly consistent (Figure 5.1). Trip 1 during November and December, 1994, averaged 1102 cfs (mean daily averages used) with a range of 952 to 1550 cfs. Trip 2 during February-March, 1995, averaged 1258 cfs with a range of 1170 to 1490 cfs. Trip 3 during August, 1995, averaged 1356 cfs with a range of 1210 to 1570 cfs. Trip 4 during September, 1995, occurred on the descending limb of a storm with flows averaging 1308 cfs and ranging from 1040 to 2080 cfs. Levene's test for homogeneity of variances indicated that variances in discharge between trips were not significantly different ($P=0.37$). A one-way analysis of variance (ANOVA) was then applied to the flow data (Zar 1984). The results of this analysis indicated that there were no significant differences in discharge between trips ($P>0.15$). This consistency in discharge between

previous
next
return to Main Menu

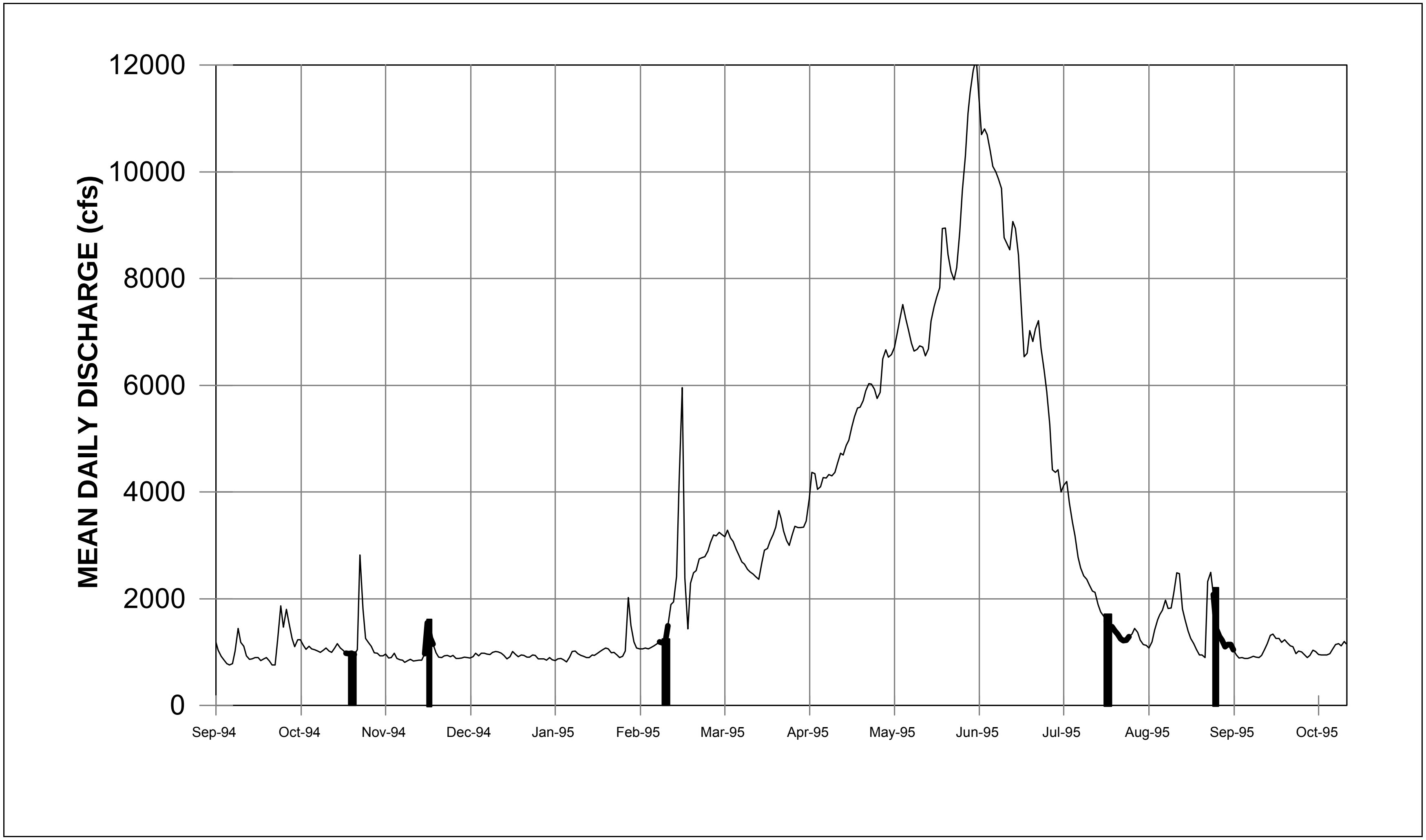

Figure 5.1. **San Juan River mean daily discharge over study period as measured at Four Corners, New Mexico gaging station. Vertical bars indicate habitat sampling trips.**

Table of Contents

trips was desirable because changes in discharge through time may influence the physical characteristics of certain habitats.

To test for differences between habitat types, the physical parameters were grouped several ways. First, we combined all the data for each habitat type collected in Section 2 only, considering that there may be spatial differences in the physical characteristics of certain types. Secondly, we examined potential spatial differences within habitat types for Sections 1, 2, and 3 during the last trip in September. Lastly, we examined temporal changes within specific habitats for Section 2 only from November, 1994, to September, 1995. The analysis for temporal differences was conducted for substrate composition and DTE only since it was hypothesized that the percentage of fine sediments would increase and DTE would decrease in certain habitats following storm events and that the reverse would occur following runoff.

Our final treatment of the data involved the use of discriminant functions analysis to determine the relative contributions of the various physical parameters measured toward explaining the overall separation between habitat groups.

Mean Water Velocity

Water velocity is a key physical characteristic separating specific habitat types and is surely the most readily distinguished feature during field observations. To test for differences between habitats using Section 2 data only, we first tested the habitat groups for homogeneity of variance, a precursor to analysis of variance (ANOVA), using Levene's Test (Zar 1984). The results indicated highly significant differences between the groups ($P<0.001$) as did the ANOVA ($P<0.001$); therefore, we elected to use Dunnett's C test to discriminate between the groups because it does not assume homogeneity of variances. In future cases where homogeneity of variance has been established, we will use Tukey's Honest Significant Difference Test, a relatively conservative multiple comparison procedure that is less sensitive to unequal sample sizes (Zar 1984).

Dunnett's C test indicated that significant differences ($P<0.05$) existed between all eight habitat types; that is, all habitat categories were significantly different from each other (Figure 5.2). As can be seen, habitats were arranged from fastest to slowest from left to right and will be presented in that order in later figures for other physical parameters. Riffles were the swiftest habitats, averaging about 100 cm/sec (Figure 5.2 and Table 5.1). Riffle-runs were much more similar to riffles than runs, averaging about 90 cm/sec. Runs were a very distinct intermediate type relative to the whole range of habitats, with less variability than riffles or riffle-runs and averaging about 60 cm/sec. Cobble shoals, eddies, slackwaters, pools, and backwaters might all be considered low velocity types, averaging less than 30 cm/sec, with the last four averaging less than 20 cm/sec. Backwaters were the only type with no measurable current, although minimum velocities of 1 cm/sec or less were measured in at least one location within the five lowest velocity habitats (Table 5.1).

previous next
return to Main Menu

Table of Contents

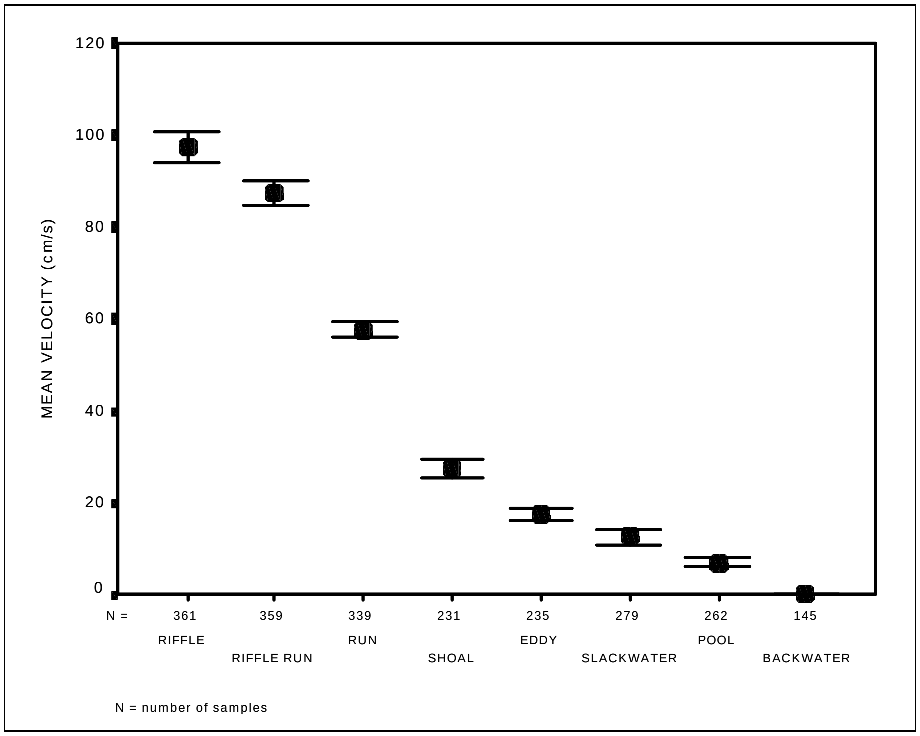

Figure 5.2. Mean (± 1 SE) Water Velocity for Eight Habitat Types in the San Juan River

Table 5.1. Mean Water Column Velocity (cm/sec) Statistics for Eight Habitat Types in Section 2 for November, 1994, to September, 1995

Habitat Type	Mean	Standard Deviation	Standard Error	95% Confidence Interval Lower	95% Confidence Interval Upper	Minimum	Maximum
Riffle	97.1	32.2	1.7	93.7	100.4	15.0	185.0
Riffle-run	87.4	26.3	1.4	84.7	90.1	32.0	175.0
Run	57.4	14.8	0.8	55.8	59.0	17.0	110.0
Cobble shoal	27.6	15.3	1.0	25.6	29.6	1.0	85.0
Eddy	17.3	11.3	0.7	15.9	18.8	0.0	57.0
Slackwater	12.6	13.3	0.8	11.0	14.1	0.0	58.0
Pool	7.0	7.1	0.4	6.1	7.9	0.0	28.0
Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0

previous
next
return to Main Menu

Table of Contents

To determine whether there were spatial differences within habitat types, we examined the data from trip 4 in September, 1995. The results were inconsistent between habitat types. Riffles, runs, and slackwaters in Section 1 had significantly lower velocities than those in the lower two sections (P<0.05; Dunnett C) (Figure 5.3). Riffle-runs had significantly lower velocities in Sections 1 and 2 than in Section 3 (P<0.05; Dunnett C). Shoals and pools had significantly lower velocities in Section 2 than in Sections 1 and 3 (P<0.05; Dunnett C), while eddies had significantly lower velocities in Section 3 than in Sections 1 and 2 (P<0.001; Tukey HSD). The high number of measurements within each habitat type (Figure 5.3) probably contributed to the high number of differences found, and some may not be particularly meaningful. However, the substantially lower velocities observed in riffles and runs in Section 1 were especially pronounced and nearly 30 cm/sec lower on average than in Sections 2 and 3. Gradient within Section 1, which includes geomorphic Reach 8 and most of Reach 7, has a channel slope of about 1.17 ft/ft, while Sections 2 and 3 probably average about 1.14 and 1.10 ft/ft, respectively. Thus, one might expect somewhat higher velocities for these habitats in Section 1 than in the lower sections on that basis. However, just the opposite was observed. The slight differences in gradient between sections are probably insufficient to produce consistent differences in riffle velocities, and so another factor must be responsible.

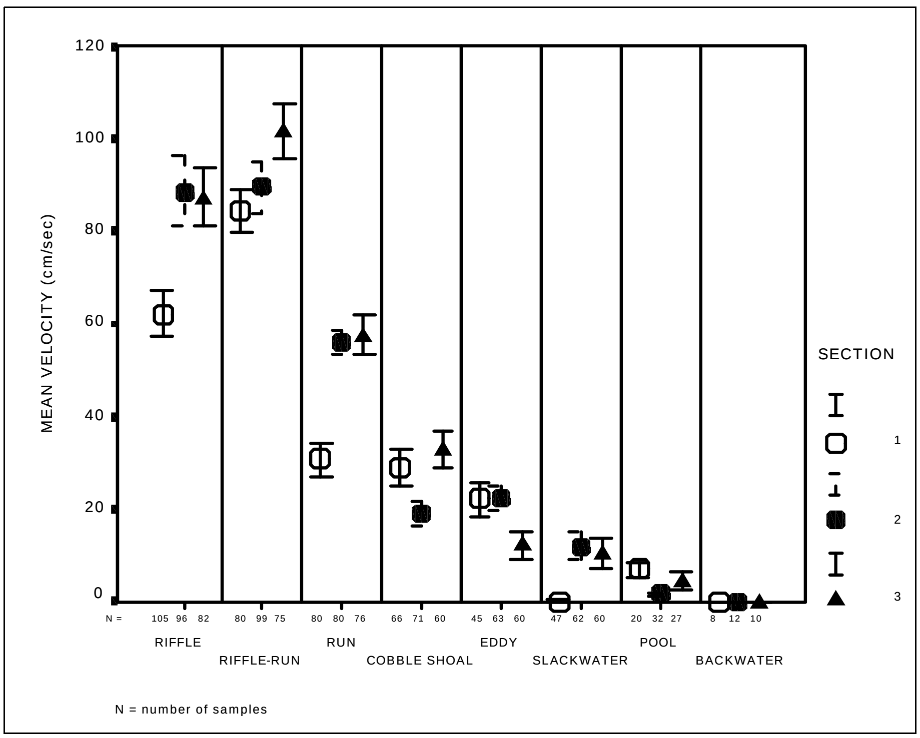

Figure 5.3. Mean (± 1 SE) Water Velocity for Eight Habitat Types in the San Juan River by Section During September, 1995

previous next
return to Main Menu

Table of Contents

Depth

Significant differences in water depth for the eight habitat types were detected for nearly every comparison ($P<0.05$; Dunnett C) (Figure 5.4 and Table 5.2). However, riffles were similar in depth to slackwaters and pools, and riffle-runs were similar to eddies ($P>0.05$; Dunnett C). Runs were the deepest habitat, averaging about 0.7 m, and cobble shoals were the shallowest at about 0.15 m. There were clear disparities between the three swiftest and most abundant habitats in the river (riffles, riffle-runs, and runs), with riffles being the shallowest and runs the deepest. The slowest habitats (slackwaters, pools, and backwaters) had more similar and relatively shallow depth profiles with a range of about 0.2 to 0.3 m.

A variety of spatial differences in depth for particular habitat types were observed, but a few are noteworthy (Figure 5.5). Riffles were significantly shallower in Section 1 than in the other two sections ($P<0.05$; Dunnett C). The more shallow nature of these habitats in the upper section may have been correlated with the lower velocities observed there (Figure 5.3). Velocities tend to be reduced in the more shallow portions of riffles. Conversely, slackwaters ($P<0.05$; Dunnett C), eddies ($P<0.001$; Tukey HSD), and pools ($P<0.05$; Dunnett C) were deeper in Section 1 than either Section 2 or 3 or both. The river is relatively confined throughout its upper portion in this Section, with the narrowest valley width within the study area (Bliesner 1999). This may contribute to any overall increase in channel depth, favoring the creation of deeper "holes". Most likely the largest contributing factor, however, is the lower suspended sediment load in this section relative to the other sections

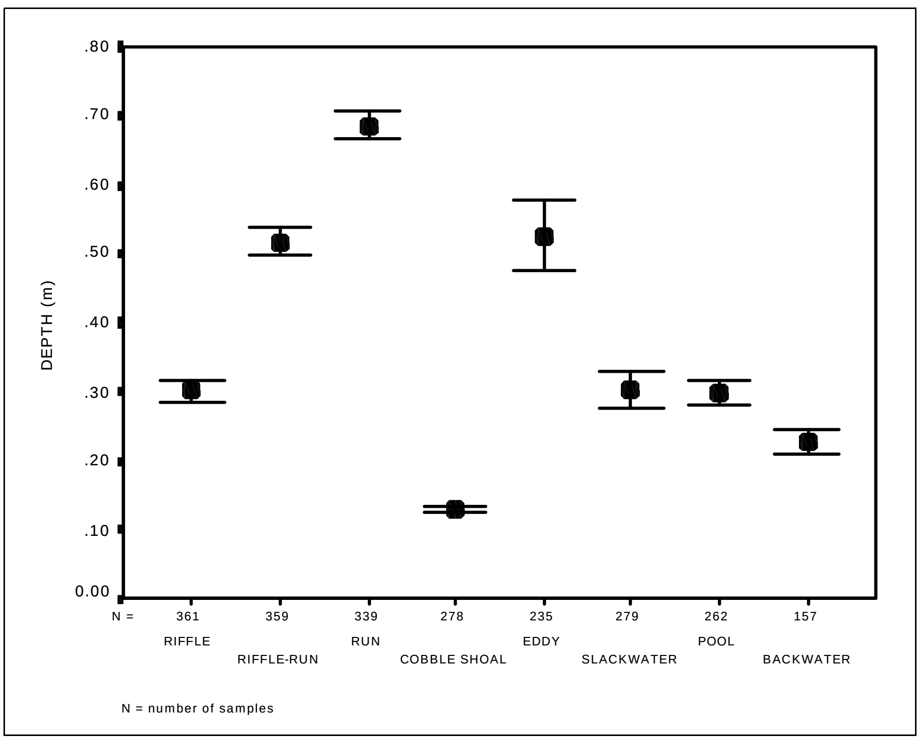

Figure 5.4. Mean (± 1 SE) Depth for Eight Habitat Types in the San Juan River

previous
next
return to Main Menu

Table of Contents

Table 5.2. Water Depth (m) Statistics for Eight Habitat Types in Section 2 for November, 1994, to September, 1995

Habitat Type	Mean	Standard Deviation	Standard Error	95% Confidence Interval Lower	95% Confidence Interval Upper	Minimum	Maximum
Riffle	0.30	0.15	0.008	0.29	0.32	0.06	0.82
Riffle-run	0.52	0.18	0.009	0.50	0.54	0.18	1.04
Run	0.69	0.19	0.010	0.67	0.71	0.15	1.16
Cobble shoal	0.13	0.05	0.003	0.12	0.14	0.03	0.30
Eddy	0.53	0.39	0.025	0.48	0.58	0.06	1.90
Slackwater	0.30	0.21	0.012	0.28	0.33	0.03	1.19
Pool	0.30	0.14	0.009	0.28	0.32	0.03	0.63
Backwater	0.23	0.12	0.010	0.21	0.25	0.06	0.61

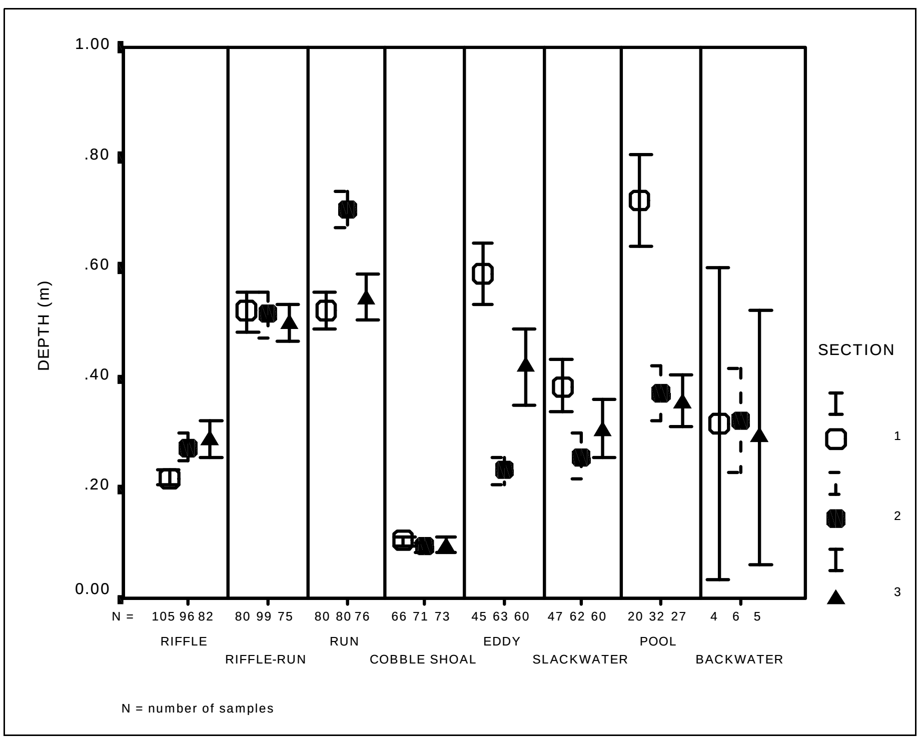

Figure 5.5. Mean (± 1 SE) Depth for Eight Habitat Types in the San Juan River by Section During September, 1995

previous
next
return to Main Menu

Depth to Embeddedness

Depth to the embedded layer was significantly different for most habitat types ($P<0.05$; Dunnett C) which would reduce filling of eddies and slackwaters over time. Pools in this upper section are actually main channel pools, characteristically deeper than the secondary channel pools that are exclusively found in the lower sections. Main channel pools typically do not occur in the lower sections except at extremely low flows and upstream of major diversions.

(Figure 5.6 and Table 5.3). However, riffle-runs were similar to runs ($P>0.05$; Dunnett C) in this measure at about 7 cm, while riffles averaged nearly 10 cm. Slackwaters, eddies, and pools were all similarly and highly embedded habitats averaging about 1-2 cm to the embedded layer ($P>0.05$; Dunnett C). There was a fairly pronounced disparity between swifter, generally cobble dominated habitats (riffles, riffle-runs, runs, and cobble shoals) and the lower velocity habitats (Figure 5.6).

Within most habitat types, there was a trend toward greater depths to the embedded layer (i.e., less embedded substrate) in upper than lower sections (Figure 5.7). Significant differences between Section 1 and Section 2 and/or Section 3 were detected within riffles (Section 2 and 3; $P<0.005$; Tukey HSD), runs (Section 2; $P<0.05$; Dunnett C), shoals and slackwaters (Section 2 and 3; $P<0.05$;

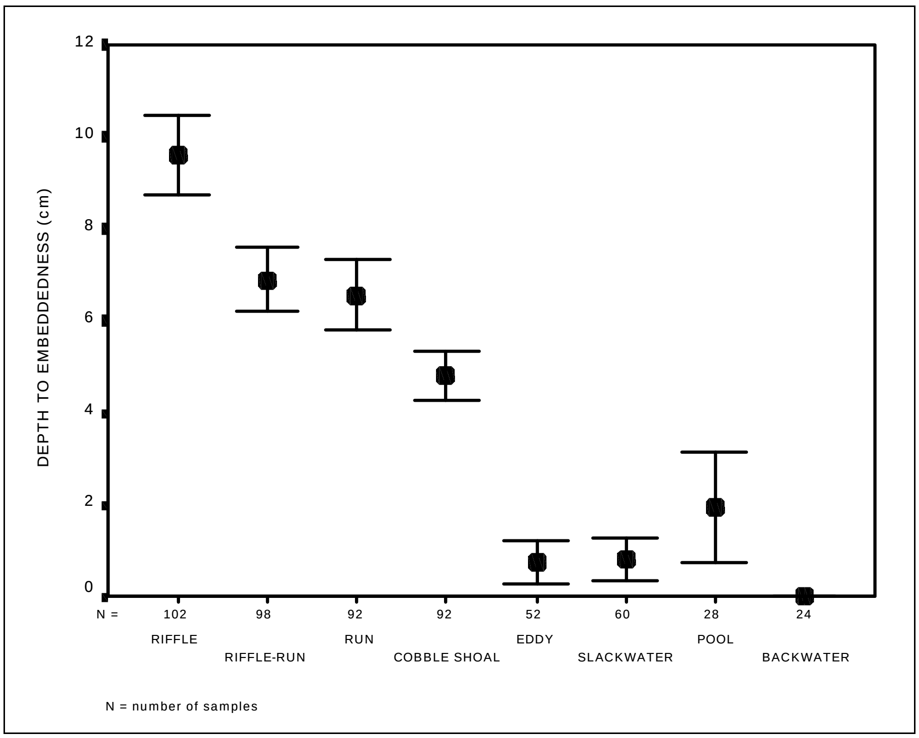

Figure 5.6. Mean (± 1 SE) Depth to Embeddedness for Eight Habitat Types in the San Juan River

Table of Contents

Table 5.3. Depth to Embeddedness (cm) Statistics for Eight Habitat Types in Section 2 for November, 1994, to September, 1995

Habitat Type	Mean	Standard Deviation	Standard Error	95% Confidence Interval Lower	95% Confidence Interval Upper	Minimum	Maximum
Riffle	9.6	4.5	0.45	8.7	10.5	0.0	22.0
Riffle-run	6.9	3.5	0.36	6.2	7.6	0.0	17.0
Run	6.6	3.7	0.38	5.8	7.3	0.0	17.5
Cobble shoal	4.8	2.6	0.28	4.3	5.3	0.0	14.5
Eddy	0.8	1.7	0.23	0.3	1.2	0.0	6.0
Slackwater	0.8	1.8	0.23	0.4	1.3	0.0	7.0
Pool	1.9	3.1	0.59	0.7	3.2	0.0	11.0
Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0

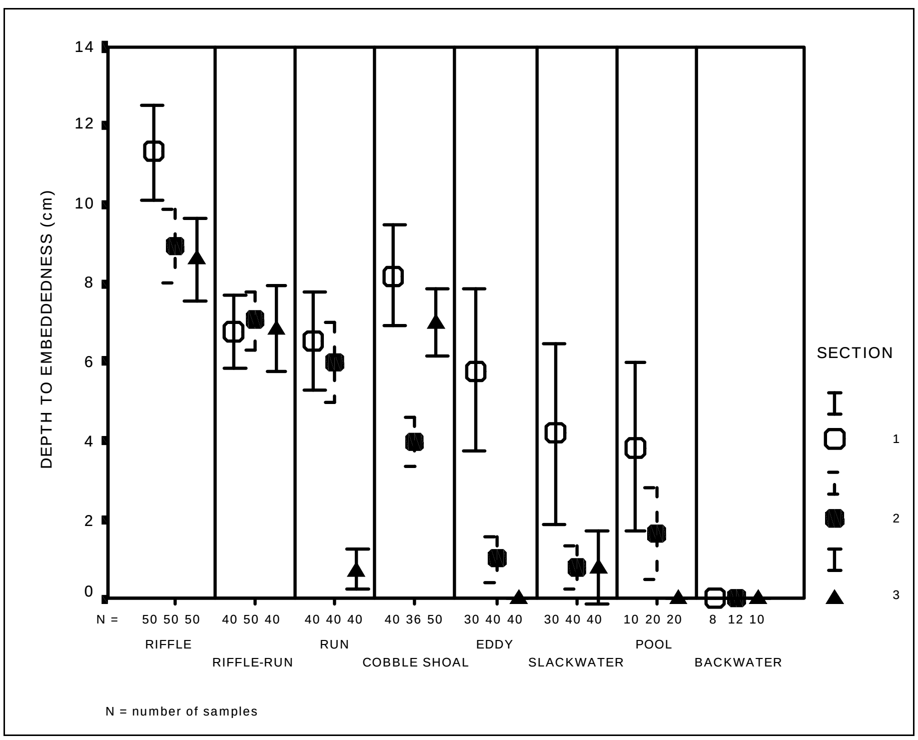

Figure 5.7. Mean (± 1 SE) Depth to Embeddedness for Eight Habitat Types in the San Juan River by Section During September, 1995

return to Main Menu
previous
next

Table of Contents

Dunnett C), and pools (Section 3; P<0.05; Dunnett C). Significant differences between Section 2 and Section 3 were detected within runs (P<0.05; Dunnett C), eddies (P<0.05; Dunnett C), and pools (P<0.05; Dunnett C). Again, our theory is that the greater suspended sediment load in the lower sections from tributary inflow contributed greatly to the more highly embedded substrate found in those lower sections.

As stated previously, it was also an objective to determine whether DTE within particular habitat types varied through time within Section 2. Specifically, the effects of runoff and storms on measures of substrate condition were of most interest. Riffles (P<0.001; Tukey HSD), riffle-runs (P<0.05; Dunnett C), and runs (P<0.001; Tukey HSD) exhibited significant declines in DTE from November, 1994 to February, 1995 (Figure 5.8). Inspection of the hydrograph indicated that one major storm occurred over this interval in early February (Figure 5.1). By August, following runoff, DTE had increased significantly in all three habitats, but still lagged behind that observed the previous November. Following two storms, DTE remained unchanged in September in all of these habitats (P>0.05). The large decline in DTE between the first two trips may reflect the accumulation of fines in the interstitial voids over the three-month period in addition to the effect of the single storm as no

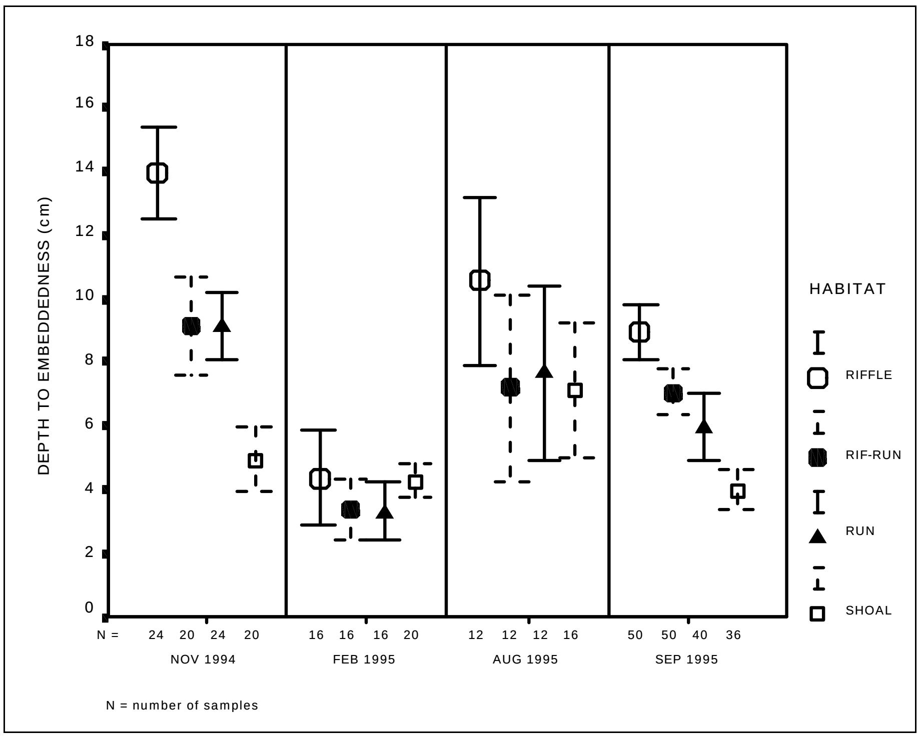

Figure 5.8. Mean (± 1 SE) Depth to Embeddeness for Eight Habitat Types in the San Juan River in Section 2 During Four periods from November, 1994 to September, 1995

previous
next
return to Main Menu

such decline was observed over a one-month period between the last two trips when two larger storms occurred. The one storm in February may also have introduced greater sediment loads than the two later storms. However, concentrations of total suspended solids during the September storm were very high at 3,000-6,500 mg/L, as measured during a related study (Ecosystems Research Institute, in press). No significant changes in DTE occurred over the study period in any of the other five habitats examined (P>0.05; Dunnett C), with all being completely embedded or nearly so.

Interstitial Sediment

A total of six interstitial sediment categories were used. These were: (1) less than 0.063 mm in diameter; (2) 0.063-0.25 mm; (3) 0.25-0.50 mm; (4) 0.50-4.0 mm; (5) 4.0-12.5 mm; and (6) greater than 12.5 mm. For the sake of brevity, only the smallest and largest fractions, encompassing the range of sediment sizes, will be considered in the following analyses. However, all size fractions will be considered in the discriminant analysis at the end of this section.

Particles <0.063 mm

Ultra-fine particles less than 0.063 mm displayed an increasing pattern as expected in lower velocity habitats (Figure 5.9); however, due to inequality of variances between groups (P<0.001; Levene's Test) these differences were not significant (P>0.05; Dunnett C). These fine sediments were totally lacking in riffles and riffle-runs, the swiftest habitats, but represented about 5-10% of the interstitial sediment from samples in runs and cobble shoals. In the remaining lower velocity habitats it represented only about 7-15% of the sediment present on average.

Examination of the presence of these ultra-fine particles in habitats within the three sections during September, 1995 revealed no significant differences by section for any habitat type (P>0.05; ANOVA) (Figure 5.10). Runs, eddies, slackwaters, and pools all showed trends toward increasing percentages of these fines in lower sections; however, these differences were not significant (P>0.08; ANOVA).

Most higher velocity habitats displayed some accumulation of ultra-fines during February, 1995 (Figure 5.11), which followed soon after a storm event (Figure 5.1). Riffles exhibited a significant increase from November, 1994 (P<0.05; Tukey HSD); however, no other differences were significant (P>0.05). The accumulation of sediment in these habitats was reflected in lower DTE measurements (Figure 5.8). Lower velocity habitats exhibited similar though much larger increases in these ultra-fines over this same time interval (Figure 5.12), with significant increases occurring in eddies, pools, and backwaters (P<0.05; Dunnett C).

Table of
Contents

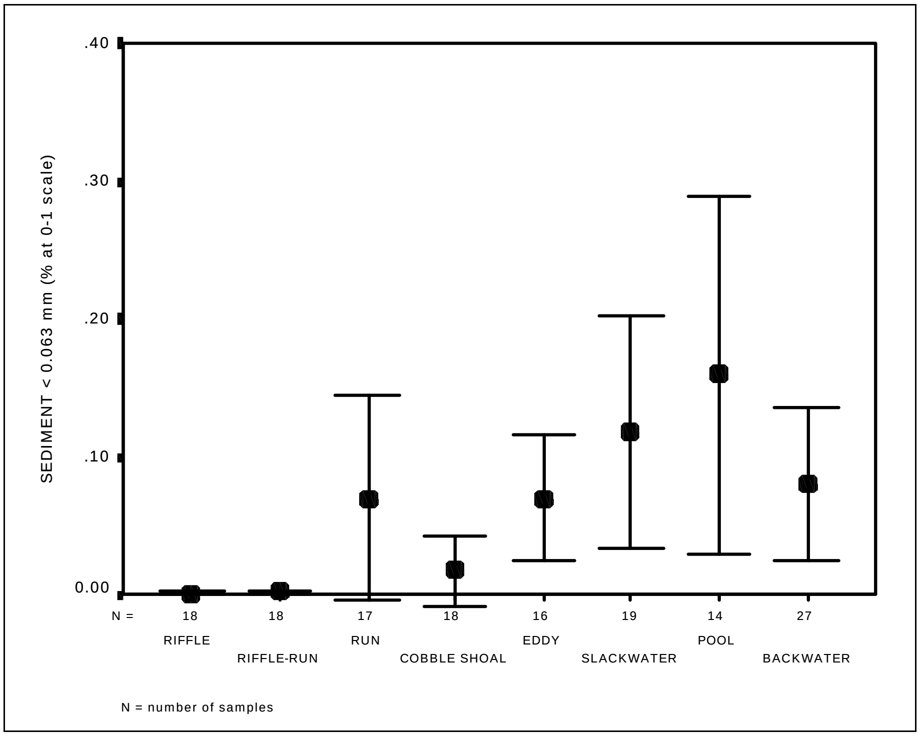

Figure 5.9. Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment <0.063 mm for Eight Habitat Types in the San Juan River

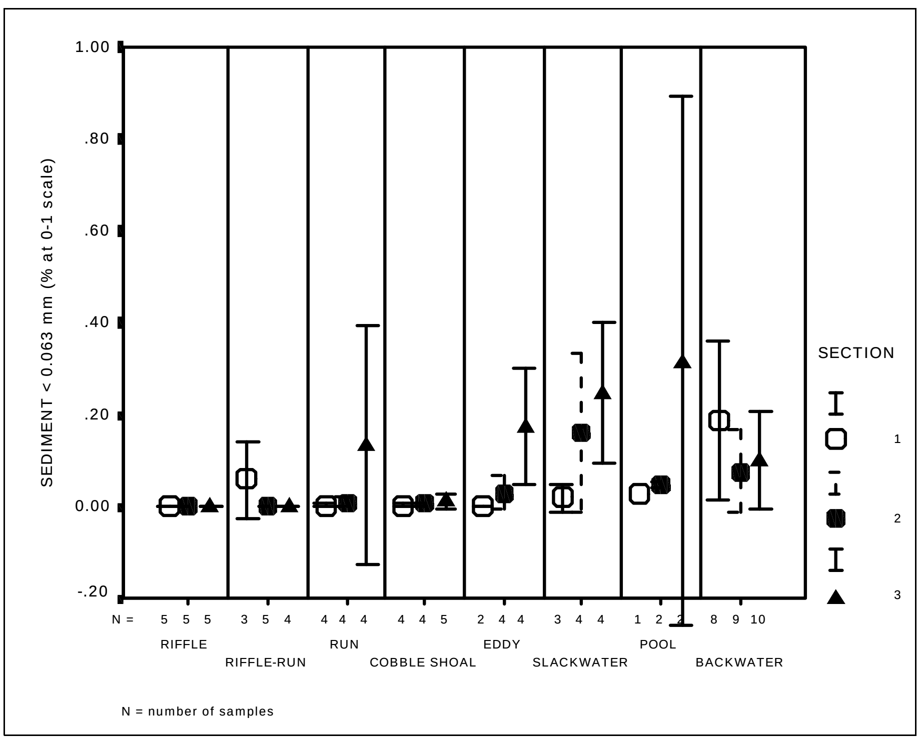

Figure 5.10. Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment <0.063 mm for Eight Habitat Types in the San Juan River by Section During September, 1995

previous
next
return to
Main Menu

Table of Contents

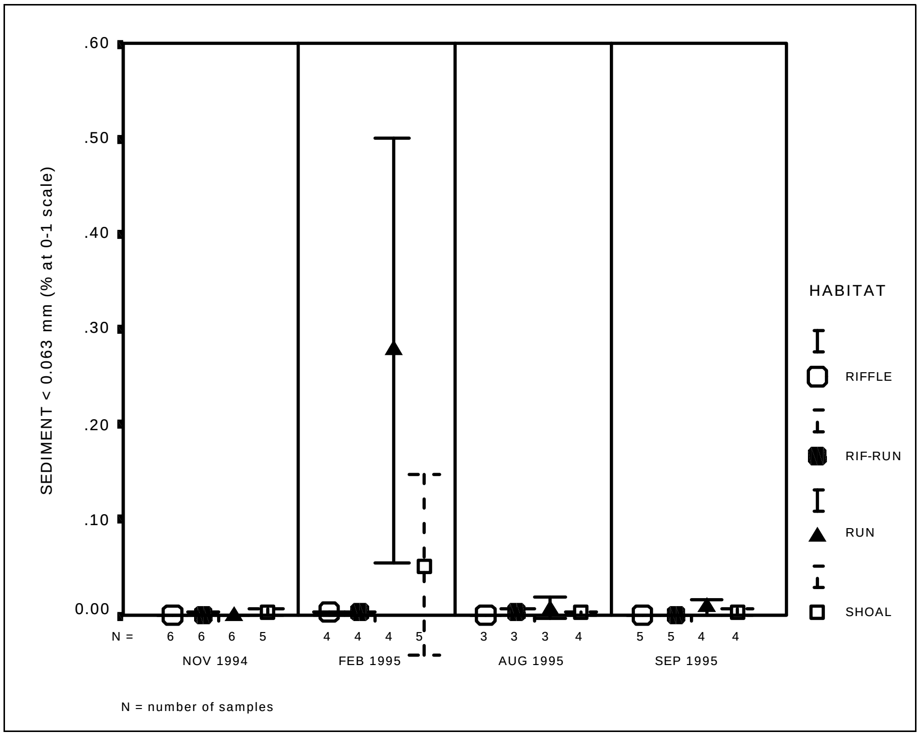

Figure 5.11. Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment <0.063 mm for Riffle, Riffle-run, Run, and Cobble Shoals in the San Juan River in Section 2

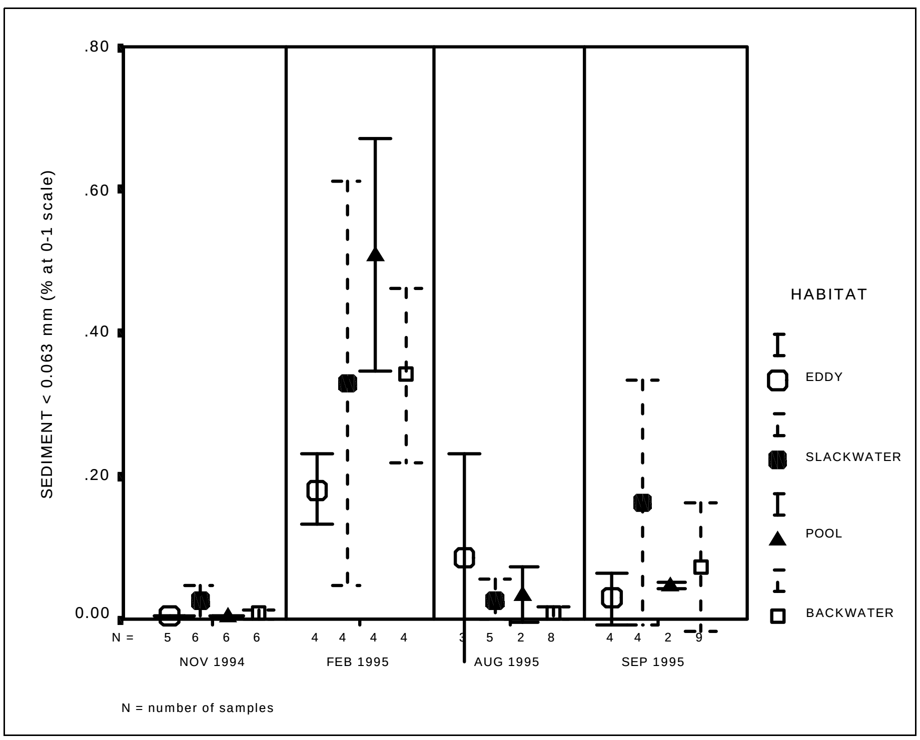

Figure 5.12. Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment <0.063 mm for Eddies, Slackwaters, Pools, and Backwaters in the San Juan River in Section 2

previous next return to Main Menu

Table of Contents

Particles >12.5 mm

The largest particles defined as >12.5 mm in diameter (approximately gravel sized) were significantly more abundant in the four higher velocity habitats ($P<0.05$; Dunnett C) than in most of the lower velocity habitats (Figure 5.13). Riffles contained significantly more of this coarser substrate than runs ($P<0.05$; Dunnett C), while there were no differences among the four lowest velocity types ($P>0.05$; Dunnett C).

Few spatial differences were observed within these habitat types during the trip in September, 1995 (Figure 5.14). Runs contained substantially more of these coarser grains in both upstream sections ($P<0.001$; Tukey HSD), while eddies had higher percentages in Section 1 than Section 3 ($P<0.05$; Tukey HSD). Generally, higher velocity habitats like riffles, riffle-runs, runs, and shoals had about 50% or more of the interstitial substrate >12.5 mm, while lower velocity types like slackwaters, eddies, and backwaters had typically less than about 20%.

No temporal differences in this substrate size were found in the four higher velocity habitats ($P>0.25$; ANOVA) except for runs which had higher levels in September, 1995 than February ($P<0.05$; Tukey HSD) (Figure 5.15). This may reflect the lingering effects of flushing of fine sediments that occurred following a relatively high runoff (Figure 5.1). No significant differences were detected over the study period within the four lower velocity habitats ($P>0.15$; ANOVA).

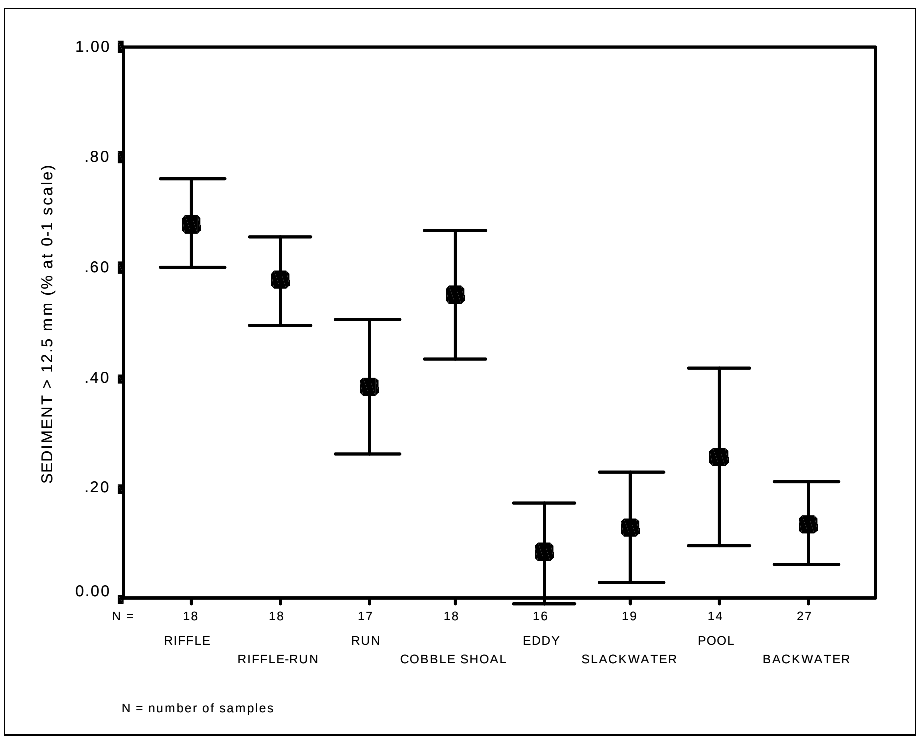

Figure 5.13. Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment >12.5 mm for Eight Habitat Types in the San Juan River

previous next
return to Main Menu

Table of Contents

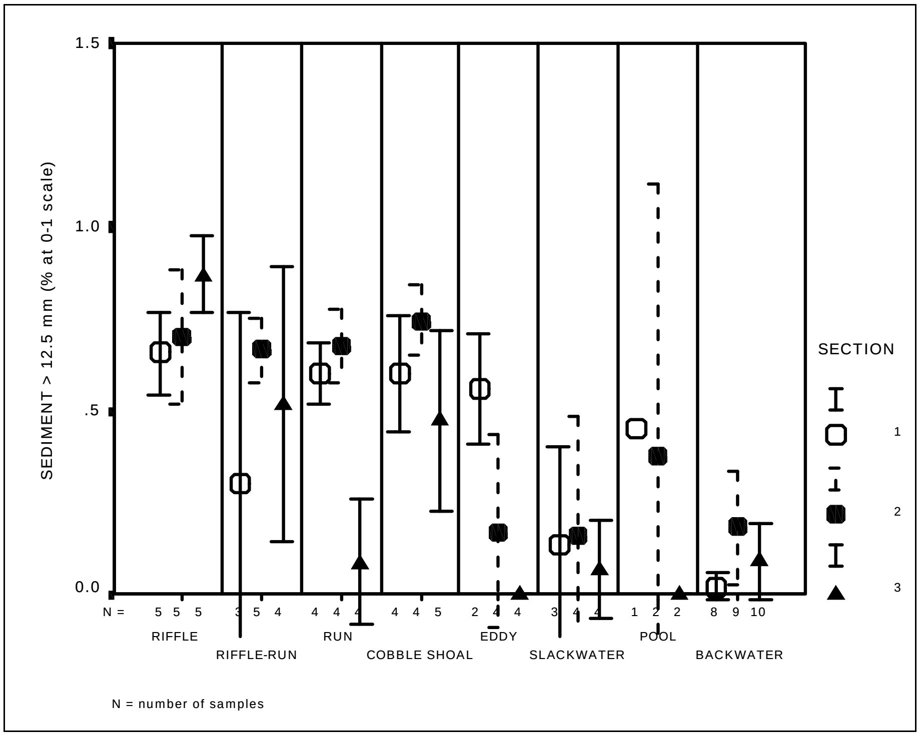

Figure 5.14. **Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment >12.5 mm for Eight Habitat Types in the San Juan River by Section During September, 1995**

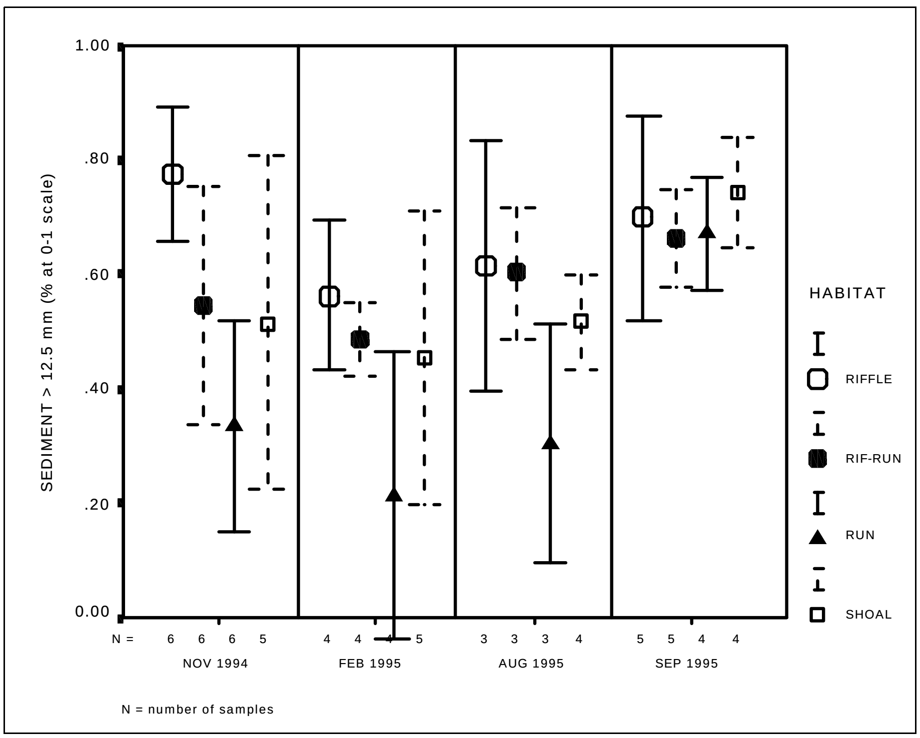

Figure 5.15. **Mean (± 1 SE) Percentage (100% at 0-1 scale) of Sediment <0.063 mm for Riffle, Riffle-run, Run, and Cobble Shoals in the San Juan River in Section 2 During Four Periods from November, 1994 to September, 1995**

return to Main Menu
previous
next

Discriminant Functions Analysis

As stated previously, a discriminant analysis (DA) was performed on the physical data collected within the eight habitat types in Section 2 over the study to determine which physical parameters contributed most toward distinguishing between the groups. This type of analysis generates a discriminant function (or, for more than two groups, a set of discriminant functions) based on linear combinations of the predictor variables that provide the best discrimination between groups.

Prior to application of DA, several assumptions must be met. First, the attribute values of one parameter should not affect another. A correlation matrix revealed that the physical parameters selected were not significantly correlated ($P>0.05$), with r values ranging from -0.42 to 0.33. The second assumption requires that each parameter is multivariate normally distributed. Nonparametric testing indicated that all three parameters significantly deviated from the normal distribution ($P<0.001$; Chi-Square Test). Therefore, this assumption was violated. However, the canonical discriminant functions themselves can apparently be derived regardless of whether the data are normally distributed or not; it is the P values that become suspect. Therefore, it was felt that the violation was allowable, but that caution would be exercised in assessing the significance levels. The third assumption requires that variance-covariances across groups be equal (Duarte Silva and Stam 1995). Levene's test for homogeneity of variances indicated that all three parameters had unequal variances between habitat groups ($P<0.001$). However, this can be allowed if the variance-covariances are roughly proportional between groups (that is, proportional to their respective means). This appeared to be satisfied in most cases. The decision was made to continue with the analysis and thereafter determine whether the output seemed reasonable.

The first step in DA is a multivariate analysis of variance (MANOVA), which tests whether any of the parameters contributes to group separation. Higher significance levels would indicate greater contribution to group separation (Duarte Silva and Stam 1995). The results indicated that mean velocity, depth, and DTE contributed greatly to group separation ($P<0.001$; Wilks' Lambda), but that the other physical (substrate-related) parameters did not contribute to the separation ($P>0.05$). However, considering that substrate >12.5 mm was nearly significant ($P=0.09$), it was decided to include this parameter in the initial DA. Using a backward elimination approach, the remaining substrate-related variables ($P>0.30$) were discarded from the analysis.

A canonical DA was performed on mean velocity, depth, DTE, and substrate >12.5 mm for the eight habitat types. The output of this analysis is indicated in Table 5.4. Higher eigenvalues indicate greater contribution of discriminant functions to group separation. Each discriminant function represents a linear expression of some combination of the physical parameters. Canonical correlations indicate the predictive power of each function toward assigning a random sample of physical parameters to the appropriate habitat type. The percent contribution of each function to the model is also indicated. More than 70% of the variability in the groups was attributed to function 1, with approximately 22% being explained by function 2. The remaining two functions explained only about 5% of the separation between the habitat types. A plot of the first two functions illustrates their use in separating the habitats into their proper groups (Figure 5.16). The functions are described by the contributions

Table of Contents

Table 5.4. The Results of Discriminant Analysis Performed on Mean Column Velocity, Depth, DTE, and Substrate Larger than >12.5 mm Data Collected from Eight Habitat Types in the San Juan River

Function	Eigenvalue	% of variance	Cumulative %	Canonical correlation
1	4.374	72.3	72.3	0.902
2	1.337	22.2	94.5	0.756
3	0.272	4.5	99.0	0.463
4	0.063	1.0	100.0	0.244

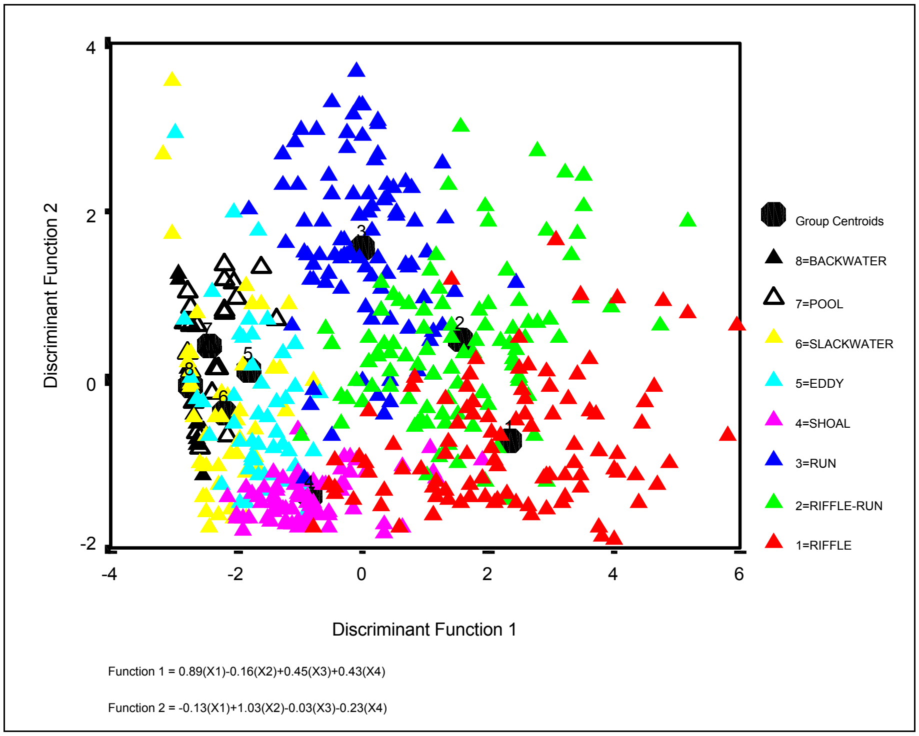

Figure 5.16. Plot of Primary Functions Derived from Discriminant Functions Analysis for Eight Habitat Types in the San Juan River

previous next
return to Main Menu

of velocity (X1), depth (X2), DTE (X3), and substrate >12.5 mm (X4). As can be seen, function 1 is largely driven by the influence of velocity, while function 2 is driven primarily by depth. Riffles, riffle-runs, runs, and cobble shoals emerge as very distinctive habitats, while the lower velocity habitats appear to be more similar to each other, but still emerging as separate groups.

CONCLUSIONS

In summary, during this study it was found that the eight habitat types selected significantly differed in most cases with respect to mean velocity, depth, and DTE. Substrate composition also differed between some habitats with generally finer substrates being more abundant in lower velocity types and coarser substrates in higher velocity types. DTE tended to be higher in most habitats in the most upstream section below Navajo Dam, indicating less embedded substrate in those areas. Highly reduced sediment loads in the upper section was a likely explanation for that finding.

Storms were observed to increase the percentage of fines and/or decrease the DTE in every habitat described. Conversely, the cleansing action of high runoff was noted in nearly all habitats as well. This illustrated the necessity for considering the effect of hydrology on these particular attributes when describing specific habitats. For example, using DTE as a measure to distinguish between riffles and other relatively high velocity habitats following a large storm event might be counter-productive as riffle habitats would likely be similarly, highly embedded.

As stated previously, one goal of this study was to determine whether original habitat definitions obtained from U.S Fish and Wildlife Service and New Mexico Game and Fish personnel were accurate or of sufficient detail. At the close of this final report, we compare old and refined habitat descriptions for the eight habitat types studied (Table 5.5). Greater detail for velocity, depth, embeddedness and substrate characteristics were provided for all habitats. The only major discrepancies occurred for velocity in the old definition of riffles and runs which were substantially less than measured during our investigation.

Table of Contents

Table 5.5. Old and Revised Habitat Definitions for Eight Habitat Types in the San Juan River

Old Definition	Revised Definition
Riffle Area within channel where gradient moderate (5 cm/m), water velocity usually moderate to rapid (10 to 31 cm/sec), and water surface disturbed. Substrate usually cobble and rubble and portions of rocks may be exposed. Depth vary from <5 to 50 cm, rarely greater.	*Riffle* Area within channel where gradient is relatively steep and velocity rapid (90-100 cm/sec). Surface is usually disturbed with substrate consisting primarily of relatively loose cobble and rubble with interstitial gravels. Depths vary from about 6 to 60 cm, rarely greater, and average about 30 cm.
Riffle-run Same as run but with some surface disturbance evident, substrate usually cobble or rubble.	*Riffle-run* Area within channel where gradient is relatively steep, typically less than for riffles, with velocity moderately rapid (80-90 cm/sec) and depth typically greater than riffles at about 50 cm. Generally less surface agitation than riffles. Substrate mostly cobble and rubble, usually more embedded than riffles.
Run Typically, moderate or rapid velocity water 10-30 cm/sec and no or little surface disturbance. Depths usually 10-74 cm but may exceed 75 cm. Substrate usually sand but may be silt in slow velocity runs and gravel or cobble in rapid velocity runs.	*Run* Area within channel where gradient is moderate with little or no surface disturbance. Velocities average about 60 cm/sec with less variability than riffles or riffle-runs. Depths ranging from about 10 to 120 cm or greater, averaging about 70 cm. Substrate consists of more homogeneous mix of coarse and fine substrates, depending on local conditions, with more embedded substrate than riffles.
Cobble Shoal Generally shallow areas (#25 cm/sec) with laminar flow (very slow to slow velocity) over cobble and rubble substrates. Such areas found most often on inside curve of broad channels.	*Cobble Shoal* Generally shallow areas (10-15 cm) averaging 25 to 30 cm/sec and flowing over cobble or rubble substrate. More highly embedded than most other coarse substrate habitats. Such areas found most often on inside curve of river bends, at heads of islands, or adjacent to cobble bars.
Eddy Same as pool, except water flow usually evident (but slow) and direction typically opposite that of channel or circular.	*Eddy* Low velocity shoreline feature with current typically circular and opposite main channel flow. Velocities average 15 to 20 cm/sec with depths averaging about 50 cm at low flow, but can be much deeper at higher flows. Substrate consists of mixture of silt or sand or highly embedded gravels.
Slackwater Mid-channel habitat generally located below sand shoals or other instream structure where decreased velocity provides resting areas for fish.	*Slackwater* Low velocity habitat (10 to 15 cm/sec) located below debris piles or bars along shoreline or mid-stream. Also found along inside margins of river bends. Depths and substrate characteristics similar to eddies.
Pool Area within channel where flow not perceptible or barely so; water depth usually $30 cm; substrate silt, sand, or silt over gravel, cobble, or rubble.	*Pool* Area within channel where velocity is very slow (5 to 10 cm/sec) and depths range from about 30 cm in secondary channel pools to 70 to 90 cm in main channel pools. Substrate consists of fines or highly embedded gravels.
Backwater Typically an embayment of channel, water depth from <10 cm to >1.5 m, no perceptible flow, substrate typically silt or sand and silt. Little or no mixing of backwater and channel water.	*Backwater* Typically an embayment of channel, with no perceptible flow and depths from <10 cm to >1.5 m at higher flows. Substrate consists of silt, sand, or highly embedded cobble or gravel.

return to Main Menu

previous